WHAT IS CLAIMED IS:

1. A system for measuring the directional spectrum of waves in a fluid medium having a substantially planar surface, comprising:

a sonar system having a plurality of transducers for generating respective acoustic beams and receiving echoes from one or more range cells located substantially within the beams, the beams being inclined at a non-zero angle with respect to the surface of the fluid medium; and

a computer program executed by a processor for calculating the directional spectrum associated with the waves from the received echoes, wherein the computer program further utilizes a sensitivity vector as part of the calculation of the directional spectrum.

2. The system of Claim 1, wherein the sonar system comprises a broadband acoustic Doppler current profiler (ADCP).

3. The system of Claim 1, wherein the received echoes are related to the current velocity within the range cells.

4. The system of Claim 1, wherein the transducers are arranged in ~~the~~ a Janus configuration.

5. The system of Claim 1, wherein the transducers are in a phased array configuration.

6. The system of Claim 1, wherein the calculation of the directional spectrum includes:

calculating a non-directional wave height spectrum;

calculating a cross-spectral matrix;

calculating the directional spectra at each observed frequency; and

calculating the dimensional directional spectrum form the non-directional wave height spectrum, the cross-spectral matrix, the directional spectra, and the sensitivity vector.

7. The system of Claim 1, wherein the fluid medium is at least in part water.

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8. A Doppler sonar system for measuring the directional spectrum of waves in a fluid medium having a substantially planar surface, comprising:

a signal generator for generating a transmitted signal;

a plurality of transmitting transducers operatively connected to the signal generator, the transducers generating acoustic beams based on the transmitted signal and projecting the beams into the fluid medium, the acoustic beams further having an angular relationship to the surface of the fluid medium;

a plurality of receiving transducers for receiving samples from one or more range cells located substantially within the acoustic beams, and producing a received signal relating to the samples;

a signal processor capable of processing the received signal; and

a computer program, executed at least in part on the signal processor, for calculating the directional spectrum associated with the waves based on the received signal, wherein the computer program further utilizes a sensitivity vector as part of the calculation of the directional spectrum.

9. The sonar system of Claim 8, wherein the transmitting and receiving transducers are embodied within at least one unitary transducer element.

10. The sonar system of Claim 8, wherein the transducers are arranged in ~~the~~ a Janus configuration.

11. A system for measuring the directional spectrum of waves in a fluid medium, comprising;

a signal generator generating signals associated with one or more acoustic pulses;

a plurality of transducers transmitting the acoustic pulses into the fluid medium in respective acoustic beams, the transducers further receiving echoes generated by the acoustic pulses from one or more range cells located within the acoustic beams; and

a signal processor receiving signals indicative of the received echoes, and calculating a sensitivity vector associated with the first and second transducers.

12. The system of Claim 11, wherein the acoustic beams are inclined at a non-zero angle with respect to the surface of the fluid medium.

13. The system of Claim 12, wherein the acoustic beams project downward from the surface of the fluid medium.

14. A method of calculating the directional spectrum of a wave in a fluid medium utilizing a plurality of acoustic transducers, comprising :

generating a plurality of acoustic beams from the transducers, the beams having range cells located at least partly therein;

receiving echoes produced within an array consisting of two or more of the range cells;

processing signals indicative of the received echoes;

generating a sensitivity vector, the vector being based on the signals and the geometry of the array of range cells; and

estimating the directional spectrum of the wave based on the signals and the sensitivity vector.

15. The method of Claim 14, wherein the processing of the signals indicative of the received echoes includes:

decoding the raw data associated with the received echoes;

calculating the surface height for each acoustic beam;

calculating a mean value of current in the fluid medium; and

numerically inverting a linear dispersion relation, wherein the linear dispersion relation relates wave frequency, water depth, and wavenumber.

16. The method of Claim 14, wherein the generating of the sensitivity vector includes:

selecting at least one range cell from at least two of the acoustic beams;

calculating a plurality of velocity components for each of the selected range cells;

calculating a plurality of Fourier coefficients associated with each of the velocity components; and

calculating a sensitivity vector from the plurality of Fourier coefficients.

17. The method of Claim 14, wherein the estimating of the directional spectrum includes:

calculating the wave height spectrum S_H;

calculating the cross-spectral matrix **C**;

calculating a directional spectrum at each observed frequency; and

constructing the estimate of the dimensional wave directional spectrum from the directional spectra.

18. The method of Claim 14, wherein the sensitivity vector includes elements corresponding to surface height and pressure within the fluid medium.

19. The method of Claim 14, wherein the estimating the directional spectrum comprises maximum likelihood processing of the signals indicative of the received echoes.

20. The method of Claim 19, wherein the estimates of the directional spectrum further comprises iterative maximum likelihood method (IMLM) processing.

21. A method of measuring the directional spectrum of waves in a fluid medium using a sonar system having an upward or downward looking transducer configuration, comprising:

generating one or more acoustic beams from the transducer configuration;

measuring the current velocities within one or more range cells of the acoustic beams;

forming a sensitivity vector related to the transducer configuration using a linear wave model; and

forming a wave directional spectrum matrix using the measured current velocities and the sensitivity vector.

22. A computer program used with a sonar system for calculating the two-dimensional directional spectrum of a wave in a fluid medium from at least one set of received echoes, comprising:

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a data processor for processing the signals representative of the received echoes;

means for calculating a non-directional wave height spectrum from the signals processed by the data processor;

means for generating a cross-spectral matrix from the signals;

a sensitivity vector generator, wherein a sensitivity vector is generated relating to the configuration of the transducers of the sonar system; and

a two-dimensional directional spectrum estimator, the estimator calculating the directional spectrum from the non-directional wave height spectrum, the cross-spectral matrix, and the sensitivity vector.

23. A method of measuring the directional spectrum of waves in a fluid medium using a sonar system having an upward or downward looking transducer configuration, comprising:

generating a plurality of acoustic beams from the transducer configuration;

measuring current velocities within one or more range cells of the acoustic beams;

calculating values of wave frequency and wave number magnitude according to a linear wave dispersion relation;

forming a wave height spectrum matrix using the measured current velocities

forming a cross-spectral matrix as a function of wave frequency;

generating a sensitivity vector related to the transducer configuration of the sonar system;

using a maximum likelihood method to generate directional spectra for each observed frequency from the cross-spectral matrix and sensitivity vector; and

constructing a complete two-dimensional wave directional spectrum from the directional spectra for each observed frequency.

24. The method of Claim 23, wherein the construction of the complete two-dimensional wave directional spectrum further includes:

renormalizing the observed frequency-dependent wave directional spectrum;

determining the presence of a non-zero current; and

in the event of non-zero current, remapping the frequency and applying a Jacobian operator.

25. The method of Claim 23, wherein the maximum likelihood method used in generating the directional spectra further comprises an iterative maximum likelihood method.

26. The method of Claim 23, wherein the sensitivity vector includes elements corresponding to surface height and pressure within the fluid medium.

27. The system of Claim 1, wherein the processor is independent from the sonar system.

28. The system of Claim 1, wherein the processor is included in the sonar system.

29. The system of Claim 1, wherein the processor comprises a signal processor.